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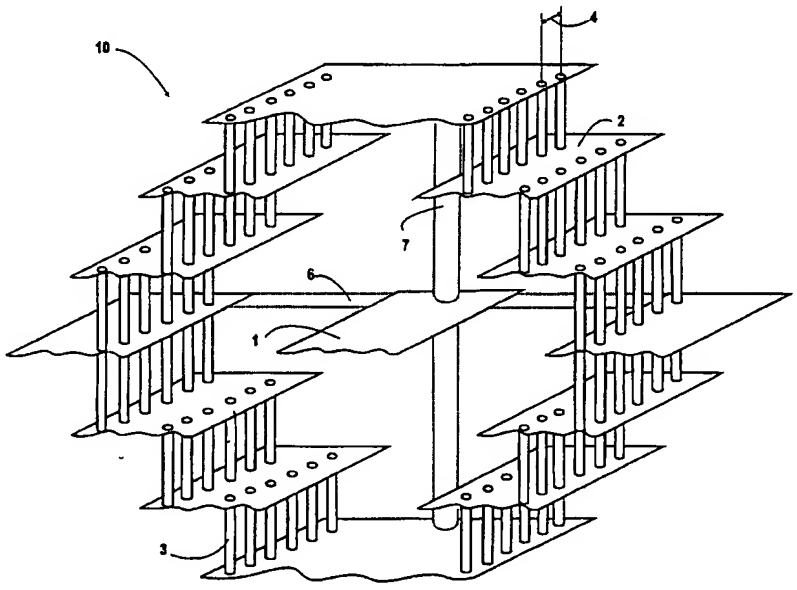
(54) Title: WAVEGUIDE IN MULTILAYER STRUCTURES



(57) Abstract: The idea of the invention is to fabricate a multilayer coaxial transmission line into a printed circuit. The outermost conductor is fabricated by conductive conduit strips in different layers, using conductive via posts in isolation layers connecting the strips. The innermost conductor can be a single conductive strip or multiple strips in different layers connected together through conductive via posts.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Waveguide in Multilayer Structures

Field of the Invention

This invention relates to waveguides, transmission lines, and resonators in multilayer printed circuit board structures. In particular the invention concerns a coaxial line structure in printed circuits.

Background of the Invention

Prior art transmission lines used in printed circuits have mainly been microstrips, coplanar waveguides, and striplines. If a coaxial line have been needed in a circuit board, the coaxial has been attached separately to the surrounding circuitry on the surface of the printed circuit. This creates a potential reliability risk due to the increased number of joints, additional electrical loss, and temperature growth related to discontinuity effects. Manufacturing is expensive because of the discrete nature of a coaxial line. Coaxial structures are also relatively large because the dielectric material in the coaxial has a low dielectric constant (ε_r = 2-4). Conventional coaxial structures also need space for supporting and protective layers around the cable.

As mentioned, microstrips, coplanar waveguides, and striplines are the usual structures in multilayer printed circuits as mentioned. These are sensitive to EMC disturbances, such as electromagnetic interference. Due to the effect of radiation, especially at high frequencies, conventional multilayer transmission lines have high transmission losses as well. Using typical multilayer transmission line structures means that only moderate Q values can be gained, making it difficult to apply multilayer ceramics technologies in high Q value applications, such as resonators.

The objective of the invention is to decrease the above-mentioned drawbacks of known solutions.

Summary of the Invention

The idea of the invention is to fabricate a multilayer coaxial transmission line into a printed circuit. The outermost conductor is fabricated by conductive conduit strips in different layers, using conductive via posts in isolation layers connecting the strips. The innermost conductor can be a single conductive strip or multiple strips in different layers connected together

through conductive via posts. The objective of the invention is achieved in a manner described in the claims.

Brief Description of the Drawings

In the following the invention is described in more detail by means of the attached figures, of which

Figure 1 illustrates an example of a coaxial structure according to the invention,
Figure 2 illustrates an example of a conductive via post structure,
Figure 3 illustrates an example of a cross-section of a coaxial structure according to the invention,
Figure 4 illustrates another example of a cross-section of a coaxial structure according to the invention,
Figure 5 shows an example of a diagram of a reflection coefficient in a coaxial structure according to Figure 4,
Figure 6 shows an example of a diagram of a reflection coefficient in a coaxial structure according to Figure 1.

Detailed Description of the Invention

Figure 1 depicts an example of the coaxial structure (10) according to the invention. The innermost line strip (1) of the multilayer structure forms a transmission line for a signal, and the outermost line strips (2) in different layers of a circuit board, which are connected by via posts (3) to each other, form a ground conductor. The outermost line strips are arranged to form as round a circle as possible in order to imitate the actual coaxial waveguide. The distance (4) between the via posts should be less than a quarter in wavelength in order to guarantee good isolation between the coaxial structure and the rest of the circuit board. The via post separation (4) must not be more than half a wavelength, since otherwise multiple transmission lines start to behave like coupled resonators, resulting in severe oscillations within the structure. The minimum length between via posts is determined by the mechanical strength of a circuit board structure.

In multilayer ceramics technology, it is easy to form via posts in isolation, which can be filled with conductive paste to form signal paths before the firing process. By using a screen printing process, it is easy to

create conductive transmission line strips as well. Via posts need not be round taps, but they can be other shapes too. Figure 2 illustrates via posts which are rectangles. The post can be placed in more than one row in order to improve isolation.

In Figure 3 another example of the cross-section of a coaxial structure is depicted according to the invention. Now the signal conductor is composed of two line strips in different layers, which are connected with via posts through isolation (5). This is to suppress conductor losses. There are also two outermost conductors in this case, i.e. Figure 3 represents a triaxial structure. The triaxial structure is especially needed, for example, in sensitive measurement devices or if good immunity to EMI disturbances is otherwise required. It is also possible to fabricate more conductors in a coaxial structure if needed, i.e. to form multiaxial structures.

The short-circuit ending of a coaxial structure is formed by using conductive strips (6) (see Figure 1),posts (7), or both, to connect the innermost conductor to the outermost.

Figure 4 shows the cross-section of a coaxial structure where the outermost conductor is in the form of rectangle. The rectangle form is easier to manufacture and more inexpensive than the structure where the outermost conductor is in the form of round. However, losses are greater in the form of rectangle. Figure 5 shows an example of a reflection coefficient (S) when the test signal is input to the rectangular coaxial line (Figure 4) whose the other end has been supplied with a short-circuit. Correspondingly, Figure 6 shows an example of a reflection coefficient when the test signal is input to the round coaxial line (Figure 1) whose the other end has been supplied with a short-circuit. The reflection coefficient is greater in the round coaxial line than in the rectangular coaxial line, i.e. there are more losses in the rectangular coaxial line. Thus it is usually desired to arrange the outermost line strips for forming as round a circle as possible.

Because the multilayer coaxial structure is integrated into a printed circuit, this is an inexpensive solution. There is more space on the surface of the printed circuit for other components. The size of the coaxial structure can be reduced if high dielectric constant material is used. Typically dielectric materials used in coaxial cables have low dielectric constant values (2...4), while in multilayer ceramics dielectric constant values range from 5 up to several hundred.

EMC problems can be avoided since the outermost line of a coaxial line can act as an EMC shield to the surrounding circuitry. This also means low radiation losses. The coaxial structure has inherently a high Q value due to its geometry. High Q value of a multilayer coaxial structure enables the usage of high Q value resonators and filters in multilayer circuit boards.

The coaxial line has a low dispersion since it is of the TEM (Transverse Electric-Macnetic) transmission line type, providing that the useof this kind of transmission line is possible at high frequencies.

The invention could be applied, for example, to either multilayer ceramic technologies, such as LTCC (Low Temperature Cofired Ceramics) and HTCC (High Temperature Cofired Ceramics), or to advanced laminated printed circuit board technology.

Although the invention has been described in the light of the above-mentioned examples, it is evident that the invention is not restricted to them, but that it can be used in other structures within the scope of the inventive idea.

Claims

1. A circuit board transmission line, c h a r a c t e r i z e d in that the transmission line includes (a) a first conductor comprising several line strips placed lengthwise on different layers of the circuit board, which several line strips are connected by conductive via posts so that they form a conductive pipe, and (b) a second conductor comprising a line strip placed lengthwise essentially into the center of the first conductor.

2. A circuit board transmission line according to claim 1, c h a r a c t e r i z e d in that the cross-section of the first conductor is essentially round.

3. A circuit board transmission line according to claim 1 or 2, c h a r a c t e r i z e d in that the second conductor consists of several line strips in different layers of a circuit board, which several line strips are connected by conductive via posts.

4. A circuit board transmission line according to claim 1, 2, or 3, c h a r a c t e r i z e d in that the line contains several first conductors.

5. A circuit board transmission line according to claim 1, c h a r a c t e r i z e d in that the short-circuit ending of the line contains conductive elements from the first conductor to the second conductor.

6. A circuit board transmission line according to claim 1, 2, 3, or 4, c h a r a c t e r i z e d in that the conductive via posts between two conductive strips in the first conductor are placed in one row parallel to the conductive strips.

7. A circuit board transmission line according to claim 1, 2, 3, or 4, c h a r a c t e r i z e d in that the conductive via posts between two conductive strips in the first conductor are placed in several rows parallel to the conductive strips.

8. A circuit board transmission line according to claim 1, 2, 3, or 4, c h a r a c t e r i z e d in that the conductive via posts are round taps.

9. A circuit board transmission line according to claim 1, 2, 3, or 4, c h a r a c t e r i z e d in that the conductive via posts are rectangular taps.

10. A resonator, characterized in that the resonator includes (a) a first conductor comprising several line strips placed lengthwise on different layers of the circuit board, which several line strips are connected by conductive via posts so that they form a conductive pipe, and (b) a second conductor placed lengthwise essentially into the center of the first conductor.

11. A resonator according to claim 10, characterized in that the second conductor comprises a line strip.

12. A resonator according to claim 10, characterized in that the cross-section of the first conductor is essentially round.

13. A resonator according to claim 10, characterized in that the short-circuit ending of the resonator contains conductive elements between the first conductor and the second conductor.

14. A resonator according to claim 10 or 12, characterized in that the second conductor has a structure similar to that of the first conductor.

15. A resonator according to claim 10, 11, 12, 13, or 14, characterized in that the conductive via posts between two conductive strips in the first conductor are placed in one row parallel to the conductive strips.

16. A resonator according to claim 10, 11, 12, 13, or 14, characterized in that the conductive via posts between two conductive strips in the first conductor are placed in several rows parallel to the conductive strips.

17. A resonator according to claim 10, 11, 12, 13, 14, or 15, characterized in that the conductive via posts are round taps.

18. A resonator according to claim 10, 11, 12, 13, 14, or 15, characterized in that the conductive via posts are rectangular taps.

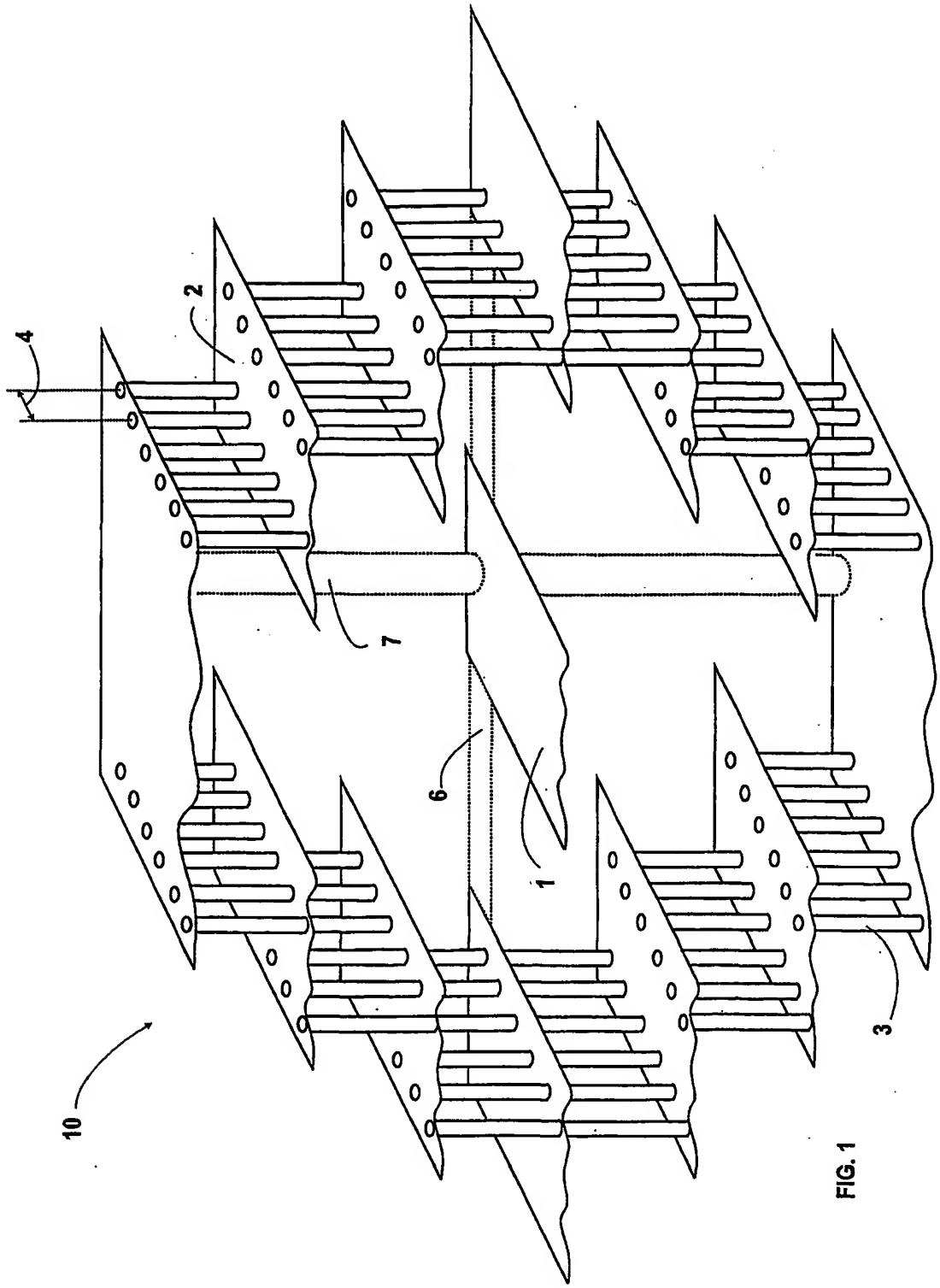

FIG. 1

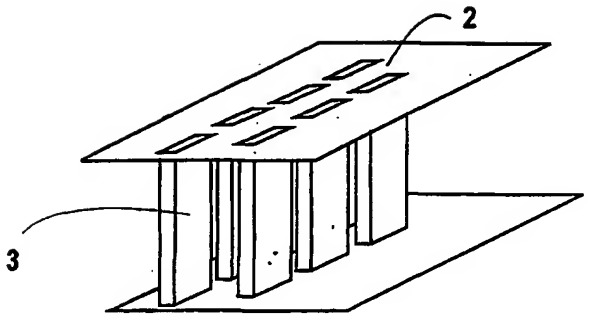

FIG. 2

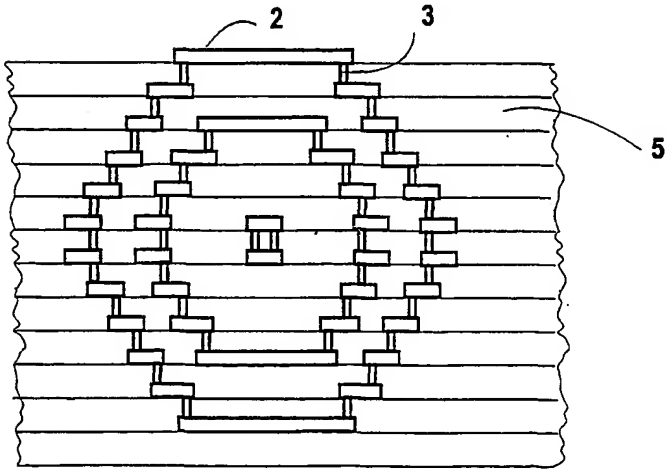

FIG. 3

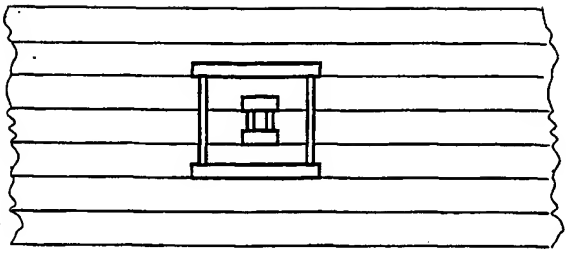

FIG. 4

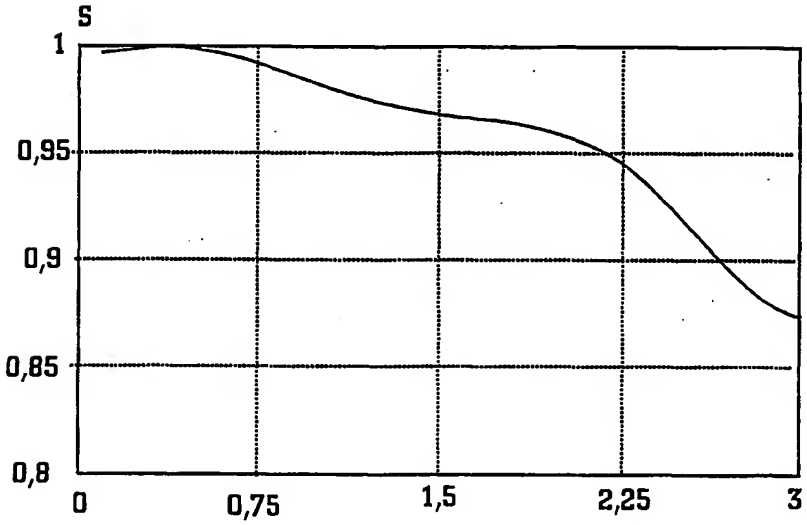

FIG. 5

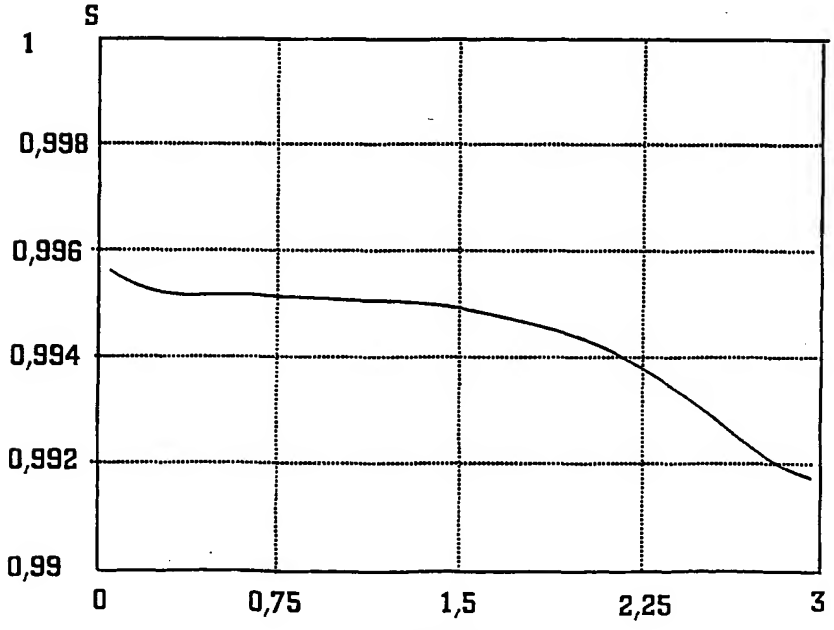

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 01/00482

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01P 3/06, H01P 7/08, H05K 3/46
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01L, H01P, H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0911903 A2 (NOKIA MOBLE PHONES LTD.), 28 April 1999 (28.04.99), column 7, line 17 - column 9, line 39, figure 3	1-3,5-18
A	JP 62259500 A (TOSHIBA KK), 11 November 1987 (11.11.87), figure 4	1,6-8,10, 15-17
A	JP 5275909 A (TDK CORP), 22 October 1993 (22.10.93)	1,5,10,11, 13,15,17,18
A	US 4673904 A (R.C. LANDIS), 16 June 1987 (16.06.87), figure 11	2,12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 October 2001	08 -10- 2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bo Gustavsson/AE Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/09/01

International application No.
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